

CLAIMS

What is claimed is:

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1. A switching circuit to linearly conduct current between a source and a load, the circuit comprising:

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a switching device coupled between the source and the load, the switching device having a conductive state in which a first portion of the current is conducted between the source and the load during a first phase of operation, the first phase of operation dependent on the magnitude of the current; and

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a current steering circuit coupled between the source and the load, the current steering circuit having a conductive state in which a second portion of the current is conducted between the source and the load during a second phase of operation.

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2. The switching circuit as recited in claim 1, wherein the switching device is in a non-conductive state during the second phase of operation.

3. The switching circuit as recited in claim 1, wherein the current steering circuit is in a non-conductive state during the first phase of operation.

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4. The switching circuit as recited in claim 1, wherein the second phase of operation occurs when the magnitude of the current is below a non-zero threshold value.

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5. The switching circuit as recited in claim 1, wherein the second phase of operation occurs when the switching device transitions from the conductive state to a non-conductive state.

6. The switching circuit as recited in claim 1, wherein the switching device transitions from the conductive state to a non-conductive state when the absolute value of the magnitude of the current falls below a non-zero threshold value.

7. The switching circuit as recited in claim 1, wherein the switching device comprises a silicon controlled rectifier (SCR).

8. The switching circuit as recited in claim 7, wherein the current steering circuit comprises a transistor to conduct the current during the second phase of operation.

9. The switching circuit as recited in claim 1, wherein the switching device comprises a pair of anti-parallel silicon controlled rectifiers.

10. A magnetic resonance imaging (MRI) system to perform an MRI scan in accordance with a pulse sequence, the pulse sequence including at least a first pulse, the system comprising:

a gradient coil assembly to generate a gradient magnetic field during the MRI scan;

an amplifier to drive the gradient coil assembly such that the gradient coil assembly generates the gradient magnetic field in accordance with the pulse sequence; and

a switch assembly to provide a conductive path between the amplifier and the gradient coil assembly, the switch assembly comprising:

a first switching device having a conductive state during a first portion of the first pulse of the pulse sequence; and

a second switching device coupled in parallel with the first switching device, the second switching device having a conductive state during a second portion of the first pulse of the pulse sequence,

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wherein the conductive path is provided between the amplifier and the gradient coil assembly during substantially the entire duration of the first pulse.

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11. The system as recited in claim 10, wherein the first portion of the first pulse of the pulse sequence is dependent on the magnitude of current conducted through the first switching device.

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12. The system as recited in claim 11, wherein the second portion of the first pulse occurs when the magnitude of the current conducted through the first switching device reaches a non-zero threshold value.

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13. The system as recited in claim 10, wherein the first switching device and the second switching device are uni-directional current-conducting devices, each of the first and second switching devices conducting current in the same direction between the amplifier and the gradient coil assembly.

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14. The system as recited in claim 10, wherein the first switching device comprises a silicon controlled rectifier.

15. The system as recited in claim 14, wherein the second switching device comprises a transistor.

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16. The system as recited in claim 10, the switching assembly comprising:

a third switching device coupled in parallel with the first switching device, the third switching device having a conductive state during a first portion of a second pulse of the pulse sequence, the second pulse having a polarity opposite of the first pulse; and

a fourth switching device coupled in parallel with the third switching device, the second switching device having a conductive state during a second portion of the second pulse of the pulse sequence, such that the conductive path is provided between the amplifier and the gradient coil assembly during substantially the entire duration of the second pulse.

17. The system as recited in claim 10, wherein the gradient coil assembly comprises a first gradient coil set and a second gradient coil set, and the switch assembly selectively couples the amplifier to either the first gradient coil set or the second gradient coil set.

18. A magnetic resonance imaging (MRI) system for acquiring MRI data, the system comprising:

a processor to control acquisition of the MRI data in accordance with a program stored in a memory, the program including an imaging protocol having a sequence of gradient pulses and a sequence of detection pulses;

a gradient amplifier to drive the gradient coil assembly in accordance with the sequence of gradient pulses;

an MRI scanner to perform an MRI scan in accordance with the stored imaging protocol, the MRI scanner comprising a magnet, a gradient coil assembly, and an RF coil assembly, the gradient coil assembly generating a gradient magnetic field in accordance with the sequence of pulses;

a switch assembly coupled between the gradient amplifier and the gradient coil assembly to provide a conductive path therebetween, the switch assembly comprising:

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a first switching device having a conductive state during a first portion of a first gradient pulse; and

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a second switching device coupled in parallel with the first switching device, the second switching device having a conductive state during a second portion of the first gradient pulse,

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wherein the conductive path is provided between the gradient amplifier and the gradient coil assembly during substantially the entire duration of the first pulse; and

an RF detector coupled to the RF coil to detect MRI data resulting from the MRI scan in accordance with the sequence of detection pulses.

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19. The system as recited in claim 18, wherein the first switching device comprises a silicon controlled rectifier.

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20. The system as recited in claim 18, wherein the switch assembly comprises:

a third switching device coupled in anti-parallel with the first switching device, the third switching device having a conductive state during a first portion of a second gradient pulse, the second gradient pulse having a polarity opposite the first gradient pulse; and

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a fourth switching device coupled in parallel with the third switching device, the fourth switching device having a conductive state during a second portion of the second gradient pulse, such that the

conductive path is provided between the gradient amplifier and the gradient coil assembly during substantially the entire duration of the second pulse.

21. The system as recited in claim 20, wherein the first switch device and the third switching device each comprises a silicon controlled rectifier.

22. The system as recited in claim 18, wherein the gradient coil assembly comprises a first gradient coil set and a second gradient coil set, and the switch assembly selectively couples the gradient amplifier to either the first gradient coil set or the second gradient coil set.

23. A method for performing a magnetic resonance imaging (MRI) scan with an MRI system including a gradient coil assembly, the MRI scan being performed in accordance with a pulse sequence, the method comprising:

receiving a pulse sequence;

generating a current to drive the gradient coil assembly in accordance with the pulse sequence, the current comprising a plurality of current pulses;

conducting the current to the gradient coil assembly through a switch assembly, the switch assembly comprising a first switching device and a second switching device coupled in parallel with the first switching device;

placing the first switching device in a conductive state during a first portion of a first current pulse, the conductive state of the first switching device dependent on the magnitude of the current during the first current pulse; and

placing the second switching device in a conductive state during a second portion of the first current pulse, such that the current is conducted to the gradient coil assembly during substantially the entire duration of the first current pulse.

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24. The method as recited in claim 23, wherein placing the second switching device in the conductive state occurs when the absolute value of the magnitude of the current is below a non-zero threshold value.

25. The method as recited in claim 23, wherein placing the second switching device in the conductive state occurs when the first switching device transitions to a non-conductive state.

26. The method as recited in claim 23, wherein the switch assembly comprises a third switching device coupled in anti-parallel with the first switching device, and a fourth switching device coupled in parallel with the third switching device, and the method comprises:

placing the third switching device in a conductive state during a first portion of a second current pulse, the second current pulse having a polarity opposite the first current pulse, the conductive state of the third switching device being dependent on the magnitude of the current during the second current pulse; and

placing the fourth switching device in a conductive state during a second portion of the second current pulse, such that the current is conducted to the gradient coil assembly during substantially the entire duration of the second current pulse.

27. The method as recited in claim 23, wherein the gradient coil assembly comprises a first set of gradient coils and a second set of gradient coils, and the method comprises:

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- coupling the switch assembly to the first set of gradient coils;
- conducting the current to the first set of gradient coils during the first pulse sequence;
- coupling the switch assembly to the second set of gradient coils;
- and
- 10 conducting the current to the second set of gradient coils during a second pulse sequence.
28. The method as recited in claim 23, comprising:
- 15 generating MRI data as a result of the MRI scan; and
- detecting the MRI data.
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